



1751

PTO/SB/26 (10-99)
Approved for use through 9/30/2000. OMB 0651-0031
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A PRIOR PATENT/APPLICATION

Docket Number: SP00-295

Application No.: 09/675,352
Filed: September 29, 2000
For: METHOD FOR PREGOBBING AN OPTICAL FIBER PREFORM AND SYSTEM PRODUCING OPTICAL FIBER THEREFROM

The owner*, Corning Incorporated, of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term defined in 35 U.S.C. 154 to 156 and 173, as presently shortened by any terminal disclaimer, of prior Patent Application No. 09/522,220. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns. In making the above disclaimer, the owner does not disclaim the terminal part of any patent granted on the instant application that would extend to the expiration date of the full statutory term as defined in 35 U.S.C. 154 to 156 and 173 of the prior patent, as presently shortened by any terminal disclaimer, in the event that it later: expires for failure to pay a maintenance fee, is held unenforceable, is found invalid by a court of competent jurisdiction, is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321, has all claims canceled by a reexamination certificate, is reissued, or is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

Check either box 1 or 2 below, if appropriate.

1. For submissions on behalf of an organization (e.g., corporation, partnership, university, government agency, etc.), the undersigned is empowered to act on behalf of the organization.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2. The undersigned is an attorney of record.

Authorization given by Corning Incorporated to charge deposit account number 03-3325 (attached is a triplicate copy of this page) for the Terminal disclaimer fee under 37 CFR 1.20(d).

Respectfully submitted,

Attorney for Assignee
Randall S. Wayland
Reg. No. 36,303
Corning Incorporated
SP-TI-03
Corning, NY 14831
(607) 974-0463

DATE: 6/30/03

Date of Deposit: 6/30/03

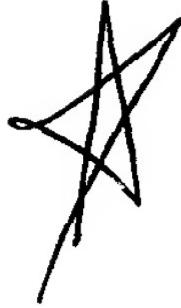
I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being deposited with the United States Postal Service on the date indicated above with sufficient postage as first class mail in an envelope addressed to the: Commissioner of Patents and Trademarks, Washington, DC 20231

Signature Randall S. Wayland

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
Form PTO/SB/96 may be used for making this statement. See MPEP § 324.
Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231.
DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

RECEIVED
JUL 03 2003
AC 1100

29/522, 220



METHOD AND APPARATUS FOR THE THERMAL TREATMENT OF AN OBJECT SUCH AS AN OPTICAL FIBER PREFORM

5

Related Applications

The invention claims priority to German Patent Application having an official file number of 19914507.5 (GR number 99P1555 DE) filed March 30, 1999.

10

Field of the Invention

The invention relates to methods and apparatus for manufacture of optical fiber preforms and optical fiber.

15

Background

The starting point of the method for the production of an optical fiber, which consists of a core (refractive index n_1), a cladding (refractive index $n_2 < n_1$) that surrounds the core concentrically, and a protective plastic layer (single or multi-layers "coating"), and which is used in communications cables as an optical transmission element, is an elongated, cylindrical quartz glass body, doped in accordance with the profile of the desired refractive index. This so-called "preform" is introduced very slowly, by means of a feed device, into the heating chamber of a high-temperature furnace, placed in the upper part of the fiber drawing tower, and heated. At temperatures $T > 2000^\circ$, the conically tapering tip of the preform is gradually transformed to a state of honey-like consistency, until finally a glass strand melts off, which consists of a core and cladding. After the quartz glass that is not suitable for the fiber production drips off, the so-called "draw bulb" is formed under the influence of

gravity. The conically tapering transition area between the quartz glass cylinder and the drawn-off fiber, whose form and dimensions depend on the high-temperature furnace and the individual drawing conditions, is referred to as the draw bulb. The glass strand of a diameter of approximately 125 µm, which is continuously drawn off from the
5 preform, then passes through the coating system, which applies the protective sheath (coating) and is located in the drawing tower directly below the diameter testing device, so that finally the fiber is placed on a supply drum and stored temporarily.

After a length of optical fiber, which is dependent on the size or mass of the
10 preform, is drawn, the production must be interrupted and the consumed preform must be replaced by a new one. Frequently, more than one hour elapses until the production of fiber with the required characteristics resumes. During this start-up time, the dripping off of the quartz glass mass that cannot be used takes place as well as the shaping of the draw bulb that satisfies the drawing conditions. The shaping of the draw bulb alone takes approximately 30 to 40 minutes.
15

Summary of the Invention

The invention concerns an apparatus and method, in particular a heating furnace and method, for the thermal treatment of an object made of a high temperature-stable
20 material, such as quartz glass of an optical fiber preform. The apparatus in accordance with the invention permits, for example, the quartz glass mass of an optical fiber preform that is not suitable for fiber drawing to melt off more rapidly than in a conventional furnace without contaminating the preform with foreign particles during
25 this process. Moreover, since preforms including pre-optimized draw bulbs are provided which are already appropriately melted off at the tip, the downtime of an optical fiber drawing apparatus can be considerably shortened.

In accordance with the invention, both the heating chamber, which has good heat insulation, and the H₂/O₂ gas burners of the heating furnace, which fire through lateral heating chamber openings onto the preform, are made of quartz glass. Thus,
30 these elements can withstand the temperatures that are generated in the chamber and that reach maximum values of T of about 2500°C in the area of the preform tip, without damage for a longer period of time. With 15-30 kW, the heating capacities of the gas burners are dimensioned in such a way that the tip of the preform, which rotates about its longitudinal axis, melts off in a drop already after approximately 20 minutes and the
35 typical draw bulb is formed. In order to optimize its shape, the preform and/or the burners can be shifted in a vertical direction, relative to one another, according to a preset program.

A contamination of the preform with foreign particles during the melting of the quartz glass mass is extensively ruled out since the combustion gases escape from the heating chamber with excess pressure (dirt does not enter due to the so-called chimney effect) and in any case, SiO₂ particles precipitate on the preform. A slight cooling of
5 the heating furnace may be required to the same degree as a flushing of the heating chamber with a protective gas.

In accordance with another aspect, the invention is method for treatment of a glass article, comprising the steps of heating one end of an optical fiber preform to form a draw bulb on the end of the preform, and then transferring the preform to a drawing tower wherein an optical fiber may be drawn therefrom. According to a preferred
10 aspect of the invention, a quartz glass mass is melted off of the preform that is not suitable for fiber drawing. Preferably also, the preform is rotated while heating.

In accordance with another aspect, the invention is method for treatment of a glass preform, comprising the step of, prior to drawing, and in a heating chamber
15 separate from a draw chamber of a draw unit, forming a pretreated preform having a draw bulb sufficient to reduce downtime of the draw unit. Preferably, the draw bulb of the preform is formed at a temperature of greater than 1800 °C.

By using appropriately pretreated preforms, that is, preforms that have optimized draw bulbs, which have already melted off at the tip, it is possible to
20 advantageously reduce the down time of a glass fiber drawing unit by up to 15-30 minutes per replaced preform. In particular, since the high temperature draw furnace of the drawing tower needs to melt less quartz glass mass this results in shorter heating-up and internal heating times. Further, the transition phase between the melting and the
25 fiber drawing takes considerably less time at the theoretical rate (the main time savings) thus the draw towers are in operation more of the time. This particularly true when the draw bulb is produced off-line in a separate heating furnace. Also, it is not necessary to move the preform as deep into the high temperature furnace (time savings because of the generally low feed rate).

30

Brief Description of the Drawings

The invention is further explained below with reference to the accompanying drawings.

35 Fig. 1 illustrates a cross-sectioned side view of an embodiment of a heating furnace for the thermal treatment of a preform in accordance with the invention.

Fig. 2 illustrates a cross sectional view of the heating furnace of Figure 1, taken along the line A-A.

5 Fig. 3 is a top cross sectional view illustrating the temperatures attained within the heating furnace during the operation.

Fig. 4 illustrates a top partially sectioned view of the structure of a quartz glass burner in accordance with the invention.

10 Fig. 5 and 6 illustrate various schematic top views the holder of the quartz glass burner in accordance with the invention.

Fig. 7 illustrates a flow diagram of the method steps in accordance with the invention.

15 **Detailed Description of the Preferred Embodiment**

The heating furnace 1, shown schematically in Figures 1 and 2, is used for the melting off of the quartz glass mass of the preform 2, that is not suitable for the fiber drawing. This furnace 1 is preferably a separate unit from the draw tower and is used to produce the draw bulb 30 on the preform, such that when it is transferred to the draw tower, the time needed to commence drawing is reduced. This reduction is due to the draw bulb having already been formed in the previous heating furnace. Essentially, the heating furnace 1 has a cylindrical heating chamber 3-5, heat insulation 6-9 surrounding the heating chamber 3-5 on all sides, several gas burners 12-13 firing onto the preform 2 through lateral heating chamber openings 10-11, and a frame, which fixes the aforementioned components and has of steel or aluminum groove profiles 14, which are square in cross-section and screw into one another. Since the SiO₂ preform 2 softens only after a temperature T of about 1750°C, an appropriately high temperature ($T \geq 1800^\circ\text{C}$) must be generated in the furnace space, so both the heating chambers 3-5 as well as the flame-producing components (burner tube, nozzles) of the gas burners 12-13 are made of a high temperature-stable material, in particular, quartz glass, which expands longitudinally only slightly during heating. Further, the use of quartz glass has the advantage that there is no contamination of the preform 2 with foreign particles and, at most, SiO₂ particles are precipitated.

35 The heating chamber 3-5 preferably has a cylindrical SiO₂ middle part 3 (a height h of approximately 470 mm, radius of about 180 mm, and wall thickness d of about 30 mm), that is provided with the gas burner openings 10-11 (with a diameter of

about 80 mm), and two quartz glass lids 4/5, which are hexagonal and whose edge projections are adapted to the placement configuration of the heating furnace. The preform 2 (includes a diameter between about 40-120 mm), which is already preferably preheated to a temperature T in the range of between about 600°C –800°C in a separate heating furnace, is introduced through a circular opening 15 of the upper lid 4 into the heating chamber 3-5 and is moved downwards until the conically tapering tip of the preform 2 is in the plane defined by the burner openings 10-11. The quartz glass dripping off from the preform 2, which rotates about its longitudinal axis, arrives at a collecting apparatus, which is not depicted, through a circular opening 16 of the lower heating chamber lid 5.

The upper and the lower heating chamber openings 15-16 have a common symmetrical axis 17, which is oriented parallel to the heating chamber longitudinal axis 18 and is shifted laterally (offset) with respect to it, in the direction of the gas burners 12-13. The axis distance designated with Δt in Figure 2 is dimensioned hereby in such a way that the preform 2 is located in the hottest point of the flames and its distance to the adjacent heating chamber wall is still sufficiently large. At the same time, the preform 2, situated in this manner, prevents the direct firing of the heating chamber wall, opposite the gas burners 12-13, which considerably reduces its thermal load. In the hottest point of the flame, adjacent to the position of the preform, the temperature reaches a value T of about 2500°C (See Figure 3); in the rest of the interior chamber of the furnace—that is, outside the flames, the temperature reaches a value of T = 1600-1800°C. With values around T = 1400°C, the maximum temperature measured at the outer chamber wall is sufficiently low so as to ensure a high service life of the heating furnace.

The heating capacity of the gas burners 12-13 is a of maximum 60 kW during operation, and more typically approximately 20-30 kW. The gas burners 12-13 are supplied with hydrogen and oxygen gases, which are conducted separately to the burners 12-13 via two O₂ connections ("outer" and "inner" oxygen) and an H₂ connection (See Figures 2 and 4). As Figure 4 shows, the outer oxygen is conducted to the burner tip via an annular nozzle 21, which is formed by the two cylindrical parts 19-20 of the gas burners 12-13. The inner oxygen is conducted into several flat nozzles 23,23',23" that are oriented parallel and located in the center of the burner head 22; and the hydrogen is conducted into the space between the flat nozzles 23,23',23" and the cylindrical part 20. As already mentioned, all components of the gas burner are made of quartz glass.

The holder of the gas burner 12,13 depicted in Figures 5 and 6 is comprised of an upper part 24 and a lower part 25 that are connected in a detachable manner to the

upper part 24, between which the gas burner 12,13 is firmly clamped or, by means of loosening a screw connection, can be guided in the direction of the double arrow. In order to be able to orient the gas burner 12,13 with respect to the preform 2, the holder is connected via a rack, which has several groove profiles 26,27 and elbows 28,29, to the frame 14 of the heating furnace. Since the holder 24,25 is also supposed to protect the silicone hoses, which bring the hydrogen and the oxygen to the corresponding burner connections, from the heat radiation of the heating furnace, it is made of a material with good heat insulation, in particular, a mixture of mica lamellae, mosecovites, phlogopite, and silicone resin.

The heat insulation 6-9 surrounds the heating chamber walls 3-5 of the heating furnace 1 on all sides (see Figures 1 and 2). In the embodiment example shown, the insulation has a middle part 6,7 which forms a hexagon, and two plate-like lids 8,9 provided with recesses 15',16'. The two lids 8,9 (having a thickness of about 20 mm) are preferably made of quartz glass. The corresponding plate-like elements of the middle part 6,7 have a thickness of about 30 mm and are made of a fireproof and oxidation-resistant insulating material that has low thermal conductivity, in particular, glass fiber or ceramic fiber material. One particularly suitable material, for example, has the tradename DOTHERM™ by DOTHERM - Isolierwerkstoffe, 44293 Dortmund, which contains the essential components of calcium silicates, special portland cements, carbon microfibers, organic fibers, and mineral binders and additives. Depending on the type, these insulating materials, which can be processed with normal hard metal tools and can be supplied in the form of plates in different sizes and thicknesses, can also withstand temperatures $T > 1000^\circ \text{C}$ (DT 1100 and DT 1200). Their thermal conductivity is about 0.114 (DT 1100) or 0.08 W/mK (DT 1200). The heat insulation 7' (preferably DT 1100), located between the gas burners 12,13 serves to protect the personnel during the loading of a preform 2 into the heating furnace 1.

In operation, as best described in Fig. 7 is illustrated in the flow chart of the method in accordance with the invention, the preform 2 is first preferably preheated to between about 600°C and 800°C in step 1 labeled 31. The preform 2 is then inserted into the heating furnace 1 in step 2 labeled 32. Within the heating chamber 3-5 as described in step 3 labeled 33, the preform 2 is heated as heretofore described to form a draw bulb 30 thereon. After this, the pretreated preform having a draw bulb 30 formed thereon is transferred to a draw furnace of a draw tower as described in step labeled 34. The draw bulb 30 formed on the end of the preform 2 is sufficient to reduce the resultant draw time required to draw a fiber from the preform in step labeled 35. In particular, if the draw bulb 30 is preoptimized, in that it is shaped appropriately to

facilitate faster draw fiber therefrom, the time savings during the draw process may be 30-50 minutes.

It will be apparent to those of ordinary skill in the art that various modifications and variations can be made to the present invention without departing from the scope of the invention. For example, it is readily possible to equip the heating furnace 1 with 5 only one H₂/O₂ burner of an appropriate capacity, or also with more than two burners, wherein the lateral burner openings should be located in the lower half, in particular, in the lower third of the heating chamber. Optionally, for example, the burners may be appropriately adapted to operate with other combustible gases also, in particular, with 10 natural gas, acetylene, butane, methane, or propane. Furthermore, the diameter of the openings 15,16, in the upper and in the lower heating chamber lids 4,5 may be selected so that they are up to 100% larger than the cross sectional area of the preform 2. Furthermore, in some cases, the openings 15, 15', 16, 16' may be other than circular, 15 i.e., adapted to the shape of the material to be treated. The burners may optionally be situated such that the burner axes 12'/13' are positioned at an angle that differs from 90°, relative to the longitudinal axis 17' of the preform 2. Further yet, it may be advantageous to provide a non-cylindrical heating chamber 3. Moreover, other high 20 temperature-resistant ceramic material may be employed instead of quartz glass. Additionally, the design of the lid, insulation, and rack may be round or other suitable shapes. Thus, it is intended that the present invention cover the modifications and variations provided they come within the scope of the appended claims and their equivalents.

Claims

What is claimed is:

5

1. Apparatus for the thermal treatment of an object (2), comprising:
 - (a) a thermally insulated heating chamber (3-5), whose walls include an upper opening (15) which is used to introduce the object (2) into the heating chamber (3-5), an exit opening (16), which is opposite the upper opening (15), and at least one lateral opening (10,11); and
 - (b) at least one burner unit (12, 13), whose flame is used to heat the object (2) and fires onto the object (2) through the lateral opening (10, 11) of the wall.

10 15 20

2. The apparatus according to Claim 1, further comprising a common symmetrical axis (17) of the upper opening (15) and the exit opening (16) that is displaced laterally in the direction of the lateral opening (10, 11), relative to a longitudinal axis (18) of the heating chamber, the longitudinal axis (18) being oriented parallel to the common symmetrical axis (17).

25 30 35

3. The apparatus according to Claim 1 wherein the heating chamber (3-5) includes a middle part (3) provided with the lateral opening (10-11), and the middle part (3) is made of a material which exhibits a melting temperature above about 1500°C and whose coefficient of thermal expansion is smaller than 10^{-6} per °C.

4. The apparatus according to Claim 3 wherein the middle part (3) of the heating chamber and at least one element (20, 22) of the burner unit (12, 13) are made of the same material.

5. The apparatus according to Claim 4 wherein the middle part (3) of the heating chamber and the element (20, 22) are made of quartz glass or ceramic.

6. The apparatus according to one of Claim 3 wherein the middle part (3) of the heating chamber is closed off at the end, by two plate-like elements (4, 5) provided with the upper opening (15) and the exit opening (16), respectively.

7. The apparatus according to Claim 6 wherein the plate-like elements (4, 5) and the middle part (3) are made of the same material.

8. The apparatus according to one of Claim 1 wherein a dimension of the upper opening and the exit opening (16) are at most 100% larger than the maximum diameter of the object (2).

5

9. The apparatus according to one of Claim 3 characterized in that the middle part (3) has a cylindrical shape.

10. The apparatus according to one of Claim 1 further comprising several burner units (12, 13), whose flames fire onto the object (2) through a lateral opening (10, 11) of the heating chamber (3-5).

11. The apparatus according to Claim 10 wherein the lateral openings (10, 11) in the lower half of the heating chamber (3) corresponding to the burner units (12, 13) are located in a plane, which is oriented approximately vertical to a longitudinal axis (18) of the heating chamber in the areas of a chamber wall close to the object.

20. The apparatus according to Claim 1 wherein the burner unit (12, 13) operates on H₂/O₂, natural gas, acetylene gas, butane gas, methane gas, or propane gas.

25. The apparatus according to Claim 1 wherein the burner units (12, 13) or a flame-producing elements (20, 22) therein are oriented to the symmetrical axis (17), which is defined by the upper opening (15) and the exit opening (16) and is laterally displaced relative to a longitudinal axis (18) of the heating chamber.

14. A method for treatment of an optical fiber preform (2), comprising the steps of:

30. a) heating one end of an optical fiber preform (2) to form a draw bulb (30) on the end of the preform (2), and

b) transferring the preform (2) to a drawing tower wherein an optical fiber may be drawn therefrom.

35. The method of claim 14 further comprising melting a quartz glass mass off of the preform (2) that is not suitable for fiber drawing.

16. The method of claim 14 further comprising rotating the preform (2) while heating.

5 17. The method of claim 14 wherein the step of heating is accomplished by at least one gas burner (12 or 13) firing onto the preform (2).

18. The method of claim 17 wherein the step of heating is accomplished by a plurality of gas burners (12, 13) firing onto the preform (2).

10 19. The method of claim 14 wherein the step of heating is accomplished by flames which fire onto the preform (2) through a lateral opening (10 or 11) in the heating chamber.

15 20. The method of claim 14 further comprising preheating the preform (2) prior to inserting the preform (2) into the heating chamber (3-5).

21. The method of claim 14 wherein prior to the heating step, the preform (2) is inserted into a heating chamber (3-5) by passing the preform (2) through an upper opening (15) of a plate-like element of the heating chamber (3-5).

20 22. A method for treatment of a optical fiber preform, comprising the step of:

25 prior to drawing, and in a heating chamber (3-5) separate from a draw chamber of a draw unit, forming a pretreated preform (2) having a draw bulb (30) sufficient to reduce downtime of the draw unit.

23. The method of claim 22 further comprising melting a quartz glass mass off of the preform (2) that is not suitable for fiber drawing within the heating chamber (3-5).

30 24. The method of claim 22 further comprising forming the draw bulb (30) at a temperature of greater than 1800 °C.

Abstract

An apparatus and method for the thermal treatment of an object, such as a glass
5 optical fiber preform. The downtime of an optical fiber drawing apparatus can be
considerably shortened, by providing preforms which have pre-optimized draw bulbs
(30). Pre-optimized draw bulbs (30) are provided which are already appropriately
10 melted off at the tip. A heating furnace (1) is used for such thermal pretreatment (pre-
optimization) of the preforms (2) and which does not contaminate the quartz glass.
15 Utilizing preforms (2) which have pre-optimized draw bulbs advantageously increased
throughput of the draw apparatus. In accordance with one embodiment, a heating
furnace (1) that meets these requirements includes a cylindrical heating chamber (3-5),
heat insulation (6-9) surrounding the heating chamber on all sides, several gas burners
(12-13) firing onto the tip of the rotating preform (2) through lateral heating chamber
openings (10-11), and a frame (14). Since the preform (2) softens after a temperature of
about $T > 1750^{\circ}\text{C}$, correspondingly high temperatures must be generated in the heating
chamber (3-5). Therefore, both the heating chamber (3-5) and the gas burners (12-13)
are made of quartz glass or a ceramic material.

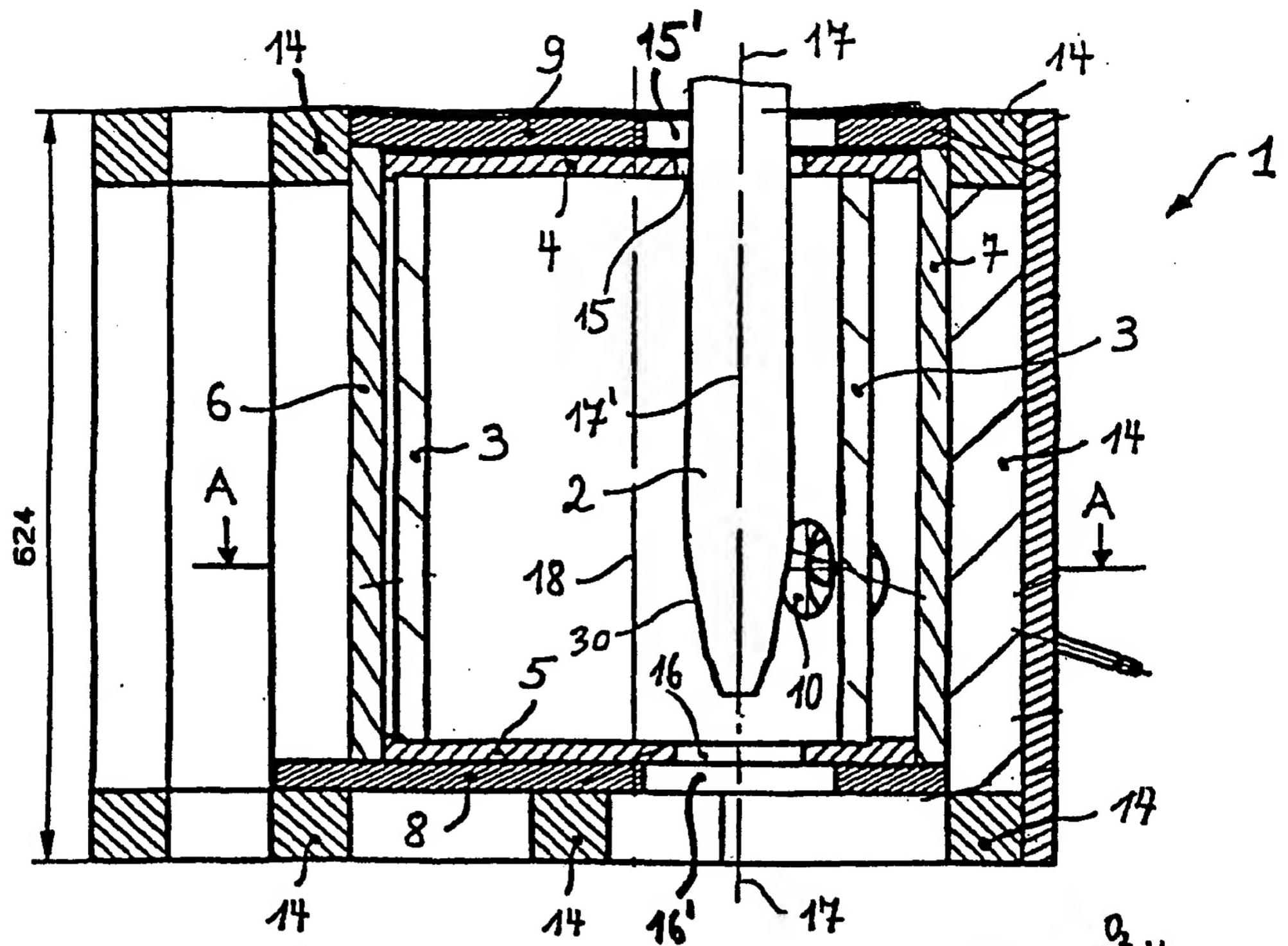
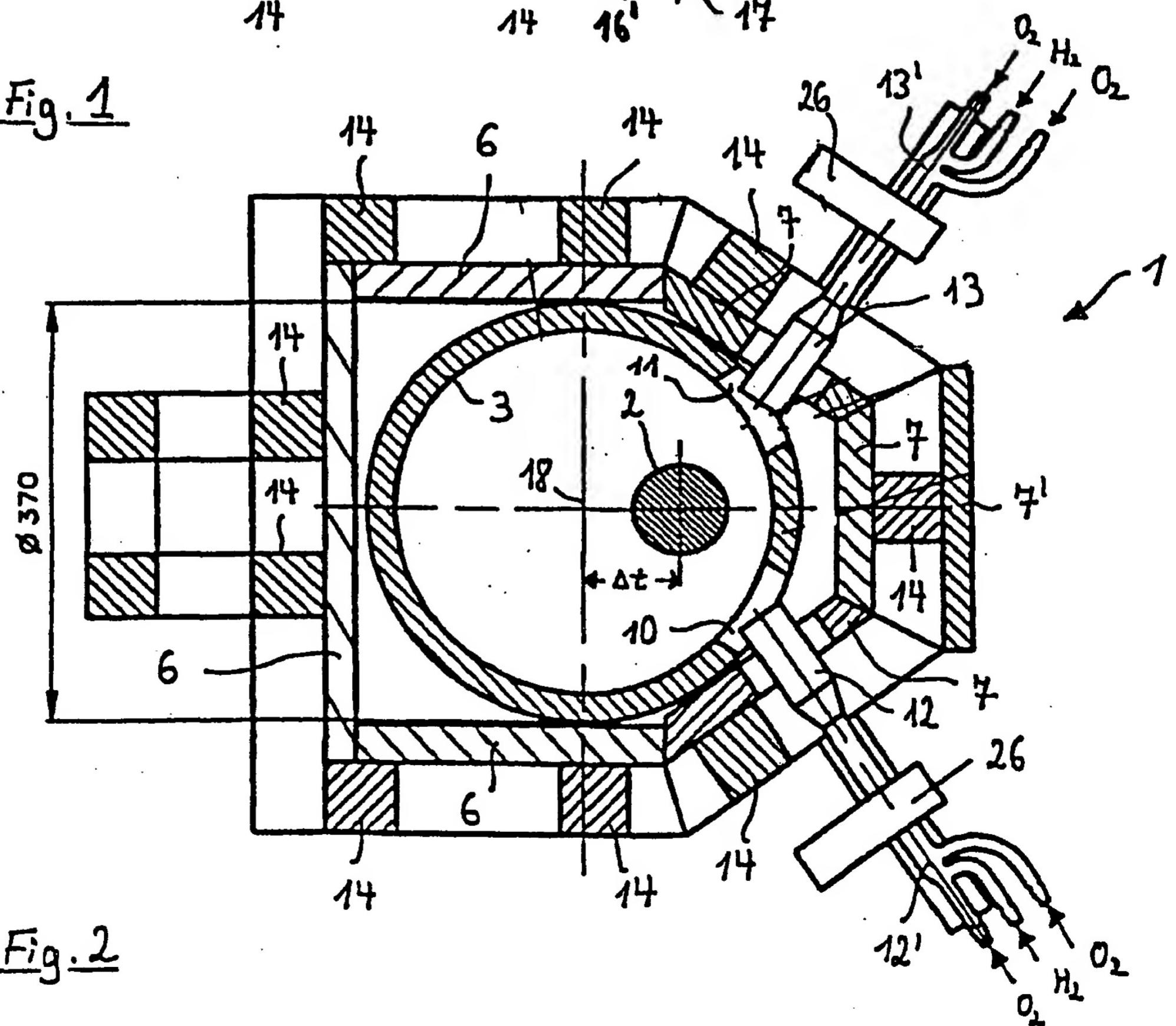


Fig. 1



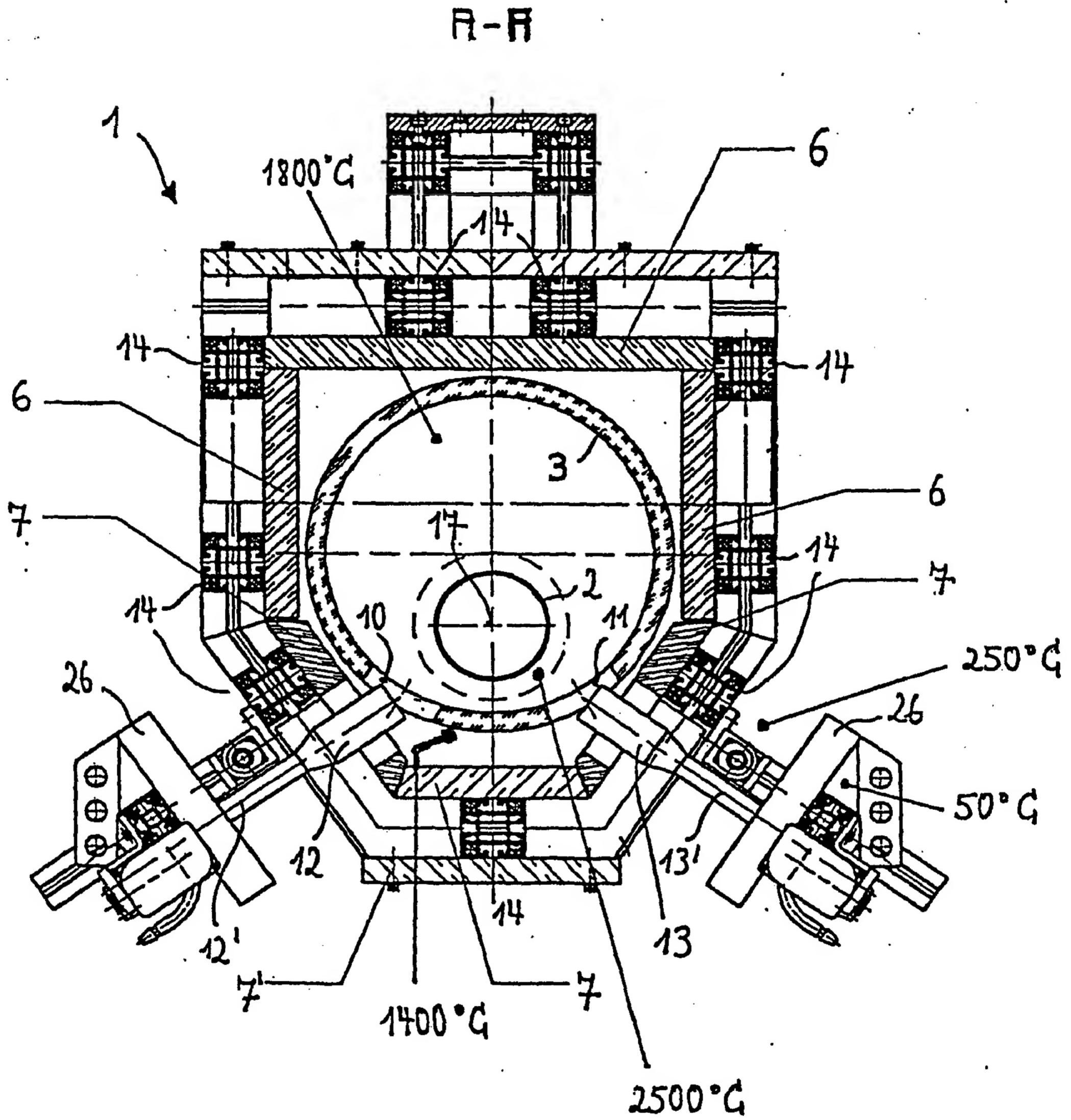
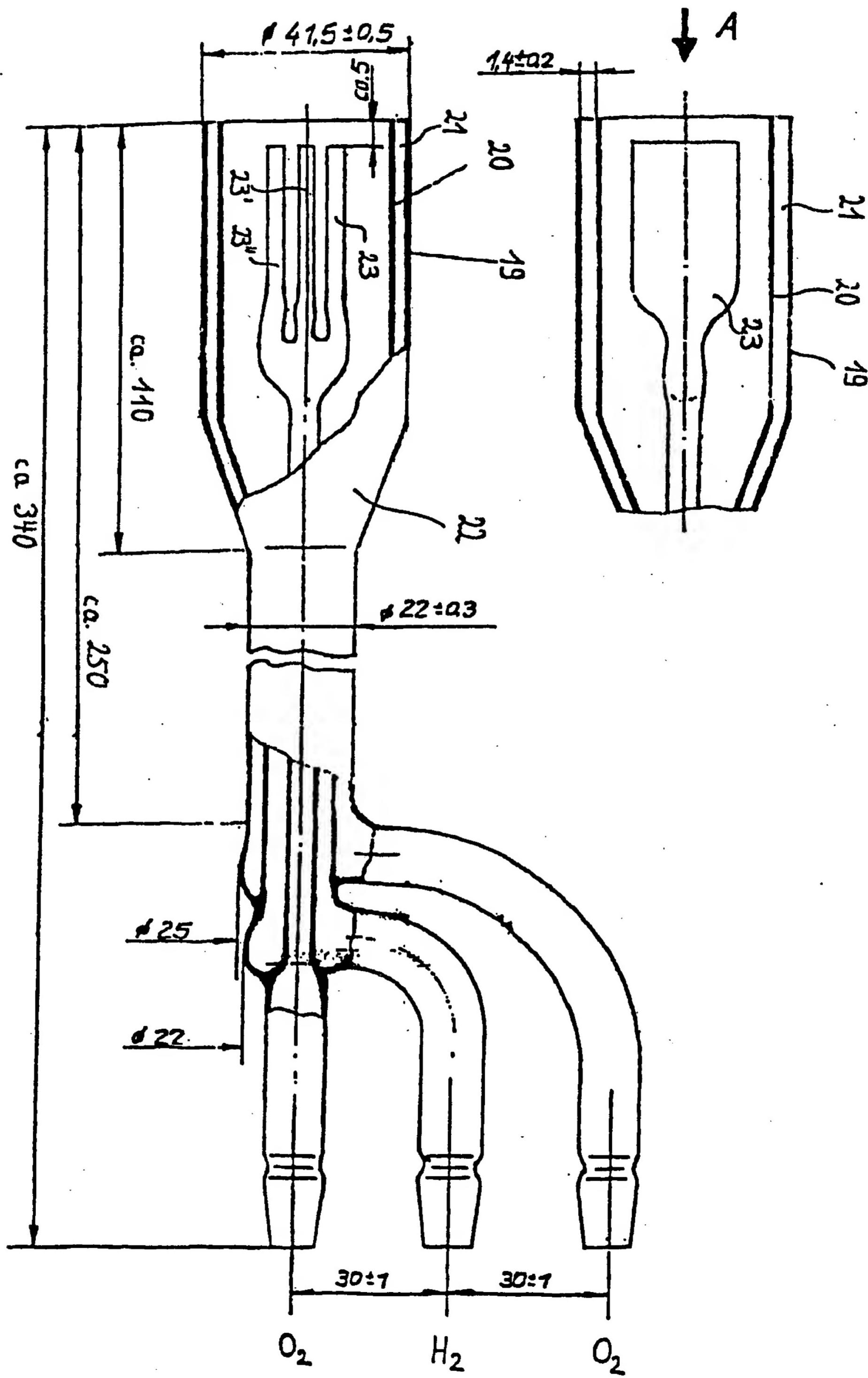


Fig. 3

Fig. 4



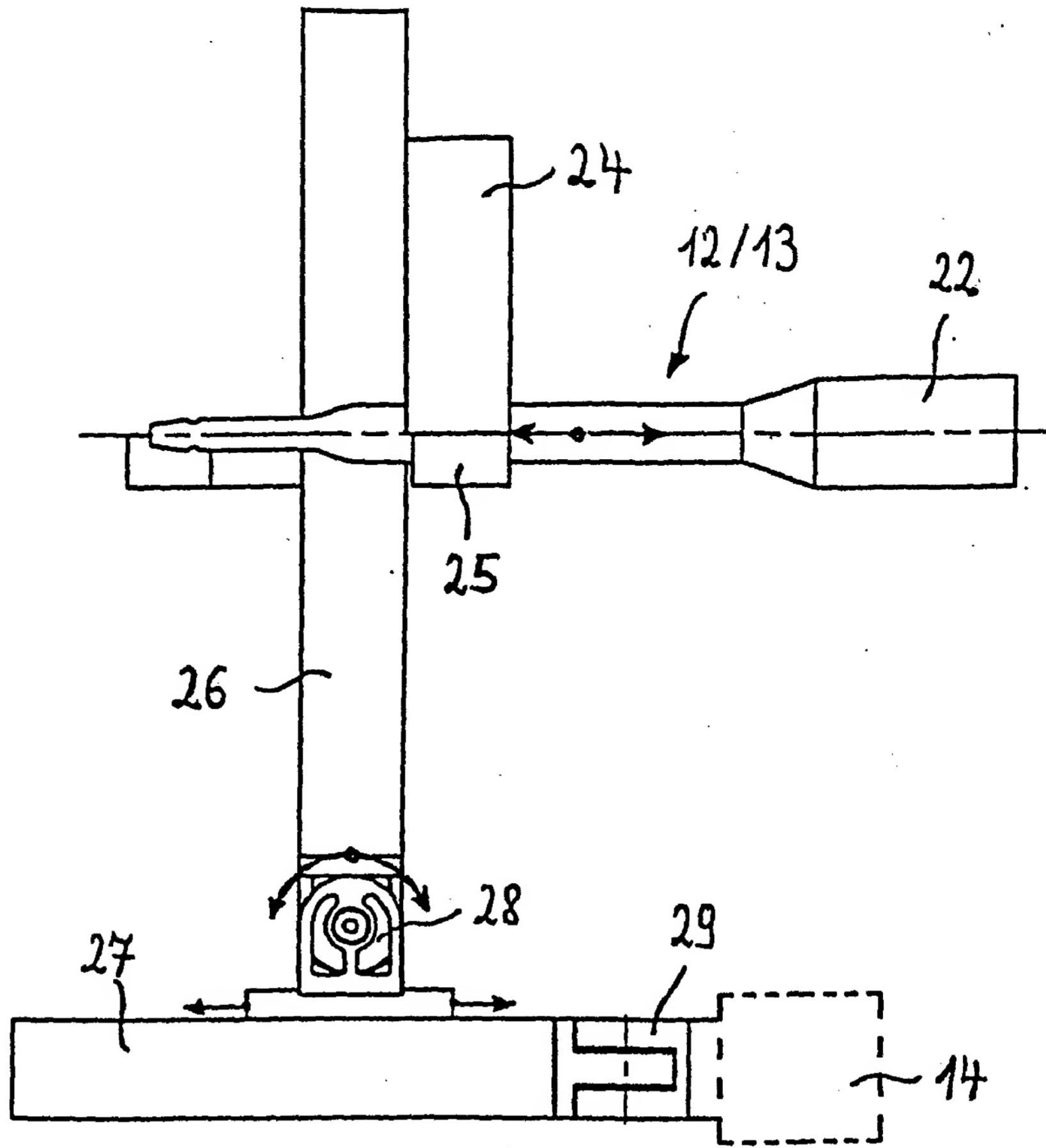


Fig. 5

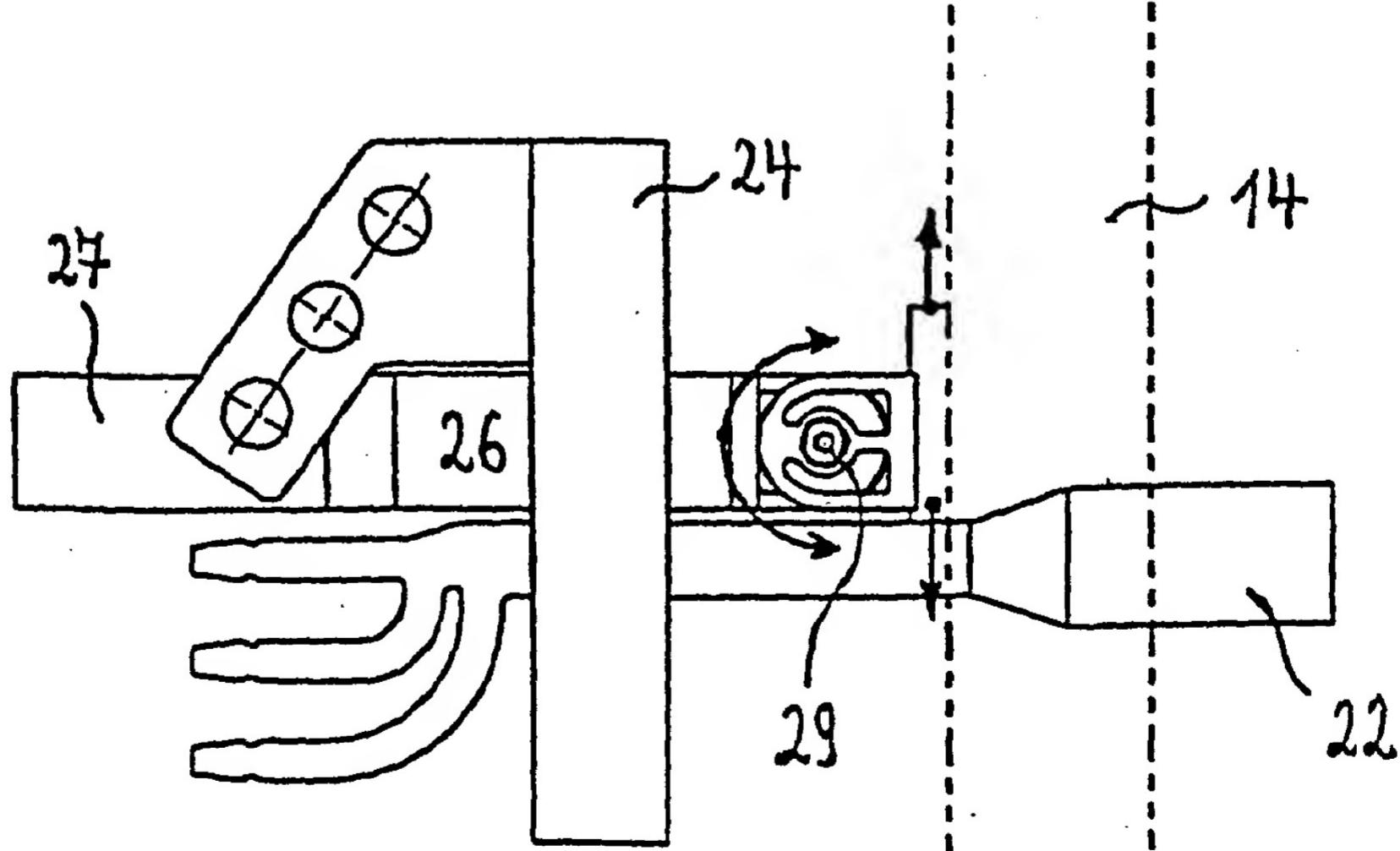


Fig. 6

Fig. 7

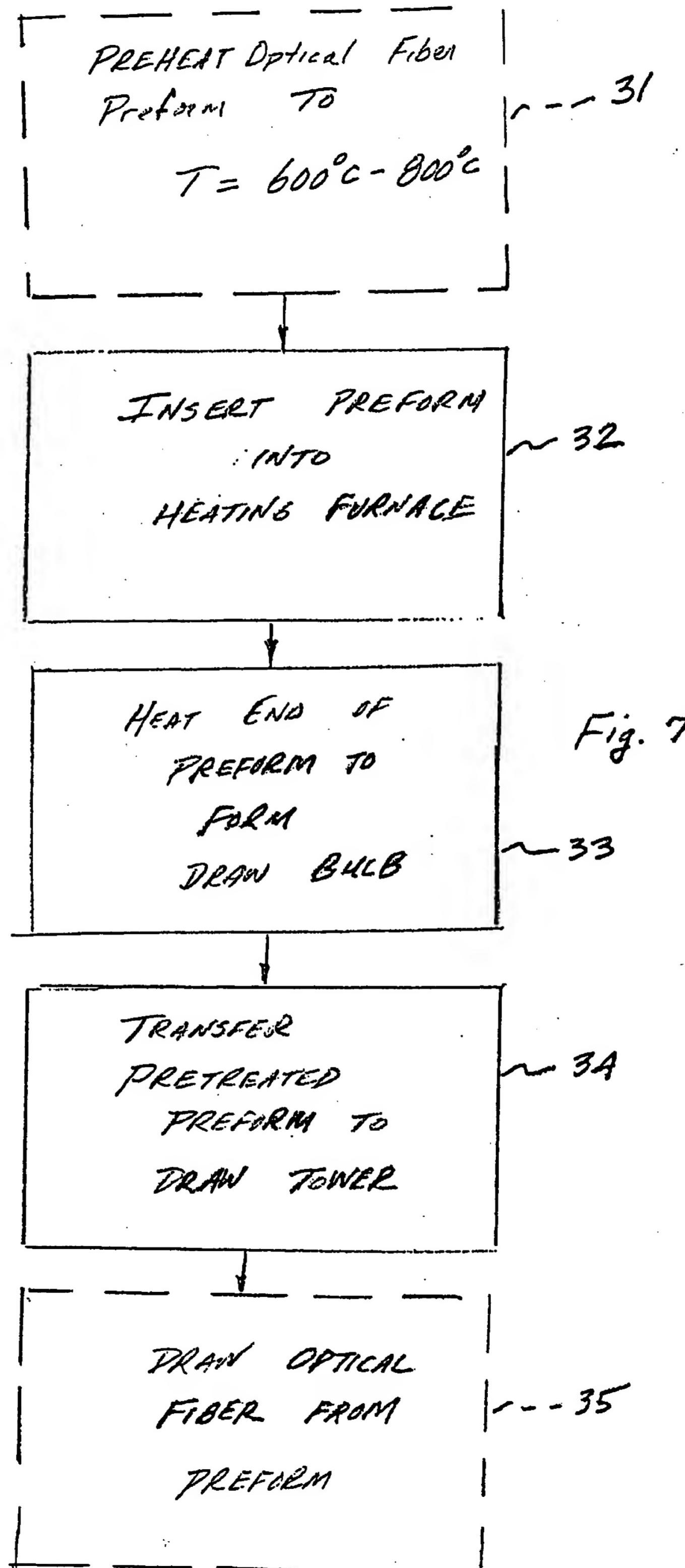


Fig. 7